WE CLAIM:

1. In a gas discharge excimer laser having a master oscillator portion, producing narrow band seed laser light output pulses, and a power amplifier portion, receiving and amplifying the narrow band seed laser light output pulses into power amplifier laser light output pulses, operating at power amplifier laser light output pulse repetition rates greater than or equal to 4000 per second, in a burst of pulses during an on period, followed by an off period, and having an electrical discharge pulse power system converting energy stored on respective master oscillator and power amplifier charging capacitors into very high voltage, short duration electrical discharge pulses across respective gas discharge electrodes in each of the master oscillator and power amplifier, through respective master oscillator and power amplifier multi-stage electrical discharge magnetic pulse compression circuitry and an electrical discharge pulse fractional turn voltage step-up transformer, an apparatus for controlling the timing of the release of the energy stored on the respective master oscillator and power amplifier charging capacitors in order to control the timing of the application of the electrical gas discharge pulse across the respective master oscillator and power amplifier electrodes, comprising:

a respective master oscillator delay command unit and power amplifier delay command unit providing a respective timing control signal to the respective master oscillator and power amplifier, determining the timing of the release of the energy stored on the respective master oscillator and power amplifier charging capacitors, based upon an initial optimal delay command value;

a laser output pulse sensor sensing a parameter of the output seed laser light pulses and amplified laser light output pulses, and providing a respective output representative of the value of the respective parameter;

a respective master oscillator and power amplifier adaptation gain unit containing a respective master oscillator adaptation gain value and power amplifier adaptation gain value;

a dithering circuit responsive to the output of the respective output pulse sensor to provide an N-plus integral value to be combined with the respective adaptation gain value in order to produce a respective delay command.

2. In a gas discharge excimer laser having a master oscillator portion, producing narrow band seed laser light output pulses and a power amplifier portion, receiving and amplifying the narrow band seed laser light output pulses into power amplifier laser light output pulses, operating at power amplifier laser light output pulse repetition rates greater than or equal to 4000 per second, in a burst of pulses during an on period, followed by an off period, and having an electrical discharge pulse power system converting energy stored on respective master oscillator and power amplifier charging capacitors into very high voltage, short duration electrical discharge pulses across gas discharge electrodes in each of the master oscillator and power amplifier, through a respective master oscillator and power amplifier multi-stage electrical discharge magnetic pulse compression circuitry and electrical discharge pulse fractional turn voltage step-up transformer, an apparatus for controlling the amount of power amplifier laser output light in the form of broadband amplified stimulated emission, comprising:

a gas discharge timing unit controlling the timing of the respective discharge in the master oscillator and in the power amplifier, comprising:

a clock providing time information to the gas discharge timing unit;

a clock triggering mechanism triggering the clock when the off period begins;

a time counter in the gas discharge timing unit providing an indication that time on the clock exceeds a selected threshold and providing a time out signal to the gas discharge timing unit when the time on the clock exceeds the selected threshold; and,

a gas discharge timing controller initiating gas discharge in the power amplifier sufficiently before or sufficiently after the discharge of the master oscillator, for at least a first discharge of the master oscillator and power amplifier after the end of the off period, to essentially prevent any significant occurrence of broadband amplified stimulated emission in the power amplifier during the at least the first discharge.

3. The apparatus of claim 2 further comprising the threshold is selected such that the gas discharge timing controller initiates the discharge in the power amplifier sufficiently before or sufficiently after the discharge in the master oscillator for the at

least the first pulse in a burst when there is a separation between bursts of a predetermined time period.

4. The apparatus of claim 2 further comprising the threshold is selected such that the gas discharge timing controller initiates the discharge in the power amplifier sufficiently before or sufficiently after the discharge in the master oscillator for the at least the first pulse in a burst for essentially all bursts, regardless of the time separating each burst.

5. A method of operating a gas discharge excimer laser having a master oscillator portion, producing narrow band seed laser light output pulses and a power amplifier portion, receiving and amplifying the narrow band seed laser light output pulses into power amplifier laser light output pulses, operating at power amplifier laser light output pulse repetition rates greater than or equal to 4000 per second, in a burst of pulses during an on period, followed by an off period, and having an electrical discharge pulse power system converting energy stored on respective master oscillator and power amplifier charging capacitors into very high voltage, short duration electrical discharge pulses across gas discharge electrodes in each of the master oscillator and power amplifier, through a respective master oscillator and power amplifier multi-stage electrical discharge magnetic pulse compression circuitry and electrical discharge pulse fractional turn voltage step-up transformer, comprising:

in a primary layer of control, timing the gas discharge in each of the master oscillator and the power amplifier based upon a respective commanded charging capacitor voltage determined for an upcoming gas discharge pulse in each of the master oscillator and the power amplifier;

in a secondary layer of control applying correction for temperature drift based upon temperature change in the electrical discharge pulse power system; and,

in a tertiary layer of control applying fast correction for respective errors in delay of the master oscillator and power amplifier.

6. The method of claim 5, further comprising the primary layer of control including utilizing a delay estimation function on a pre-established charging voltage set point to establish a predicted delay.

7. The method of claim 5, further comprising the primary layer of control including utilizing a delay estimation function on a pre-established charging voltage set point for each of the master oscillator and the power amplifier to establish a respective predicted delay.

8. The method of claim 6, further comprising the primary layer of control including utilizing a delay estimation function on a pre-established charging voltage set point for each of the master oscillator and the power amplifier to establish a respective predicted delay.

9. The method of claim 7, further comprising the secondary layer of control includes comparing the actual respective measured delay for the master oscillator and the power amplifier to the respective predicted delay.

10. The method of claim 8, further comprising the secondary layer of control includes comparing the actual respective measured delay for the master oscillator and the power amplifier to the respective predicted delay.

11. The method of claim 9, further comprising measuring a respective actual delay for the master oscillator and for the power amplifier, and comparing the actual delay to the respective predicted delay, and generating a feedback control error signal to adjust the timing of the release of the energy stored on the respective master oscillator and power amplifier charging capacitors.

12. A method of operating a gas discharge excimer laser having a master oscillator portion, producing narrow band seed laser light output pulses and a power amplifier portion, receiving and amplifying the narrow band seed laser light output pulses into power amplifier laser light output pulses, operating at power amplifier laser light

output pulse repetition rates greater than or equal to 4000 per second, in a burst of pulses during an on period, followed by an off period, and having an electrical discharge pulse power system converting energy stored on respective master oscillator and power amplifier charging capacitors into very high voltage, short duration electrical discharge pulses across gas discharge electrodes in each of the master oscillator and power amplifier, through a respective master oscillator and power amplifier multi-stage electrical discharge magnetic pulse compression circuitry and electrical discharge pulse fractional turn voltage step-up transformer, comprising:

in a primary layer of control adjusting the amount of energy stored on the respective one of the master oscillator charging capacitor and the power amplifier charging control by selecting a respective charging voltage for the master oscillator charging capacitor and for the power amplifier charging capacitor for changes in target energy of the respective seed laser light output pulse and the amplified laser light output pulse.

13. The method of claim 12, further comprising scaling the target energy by dV/dE to get the respective charging voltages.

14. The method of claim 13, further comprising in a secondary layer of control compensating for energy transients and offsets by applying an inversion waveform on a burst-by-burst basis to provide charging voltage corrections to the respective charging voltages for the master oscillator charging capacitor and for the power amplifier charging capacitor.

15. The method of claim 14, further comprising providing inversion waveforms of sufficient duration to effectively cancel the reentry slug effect.

16. The method of claim 15, further comprising in a tertiary layer of control compensating for pulse-to-pulse energy variations utilizing an integral control signal.

17. The method of claim 15, further comprising in a tertiary layer of control compensating for pulse-to-pulse energy variations utilizing an integral-integral squared control signal.

18. The method of claim 16, further comprising subtracting an energy servo output from the control signal to obtain an adaptive feed-forward control signal decoupled from the energy servo.

19. The method of claim 17, further comprising subtracting an energy servo output from the control signal to obtain an adaptive feed-forward control signal decoupled from the energy servo.

20. The method of claim 16, further comprising utilizing a high gain to minimize dose error in the presence of broadband disturbances and switching to lower gains in the absence of broad band disturbances.

21. A method of operating a gas discharge excimer laser having a master oscillator portion, producing narrow band seed laser light output pulses and a power amplifier portion, receiving and amplifying the narrow band seed laser light output pulses into power amplifier laser light output pulses, operating at power amplifier laser light output pulse repetition rates greater than or equal to 4000 per second, in a burst of pulses during an on period, followed by an off period, and having an electrical discharge pulse power system converting energy stored on respective master oscillator and power amplifier charging capacitors into very high voltage, short duration electrical discharge pulses across gas discharge electrodes in each of the master oscillator and power amplifier, through a respective master oscillator and power amplifier multi-stage electrical discharge magnetic pulse compression circuitry and electrical discharge pulse fractional turn voltage step-up transformer, comprising:

measuring the wavelength of the seed laser output light pulses and comparing the wavelength to a target wavelength on a pulse-by-pulse basis;

determining the number of pulses in a burst of pulses in which the wavelength has been measured and compared to the target wavelength on a pulse-by-pulse basis;

utilizing the difference between the measured wavelength and the target wavelength and a schedule gain index based upon the number of pulses in the burst of pulses to provided a scheduled gain output signal;

combining the scheduled gain output signal with a pre-drive derivative of the target wavelength to provide an input to a saturating integrator servo providing a saturating integrator servo output signal;

combining the saturating integrator servo output signal with the output of a diagnostic function generator to provide a line narrowing module optical drive command comprising at least one of a stepper motor command and a PZT mirror drive mechanism command.

22. A method of operating a gas discharge excimer laser having a master oscillator portion, producing narrow band seed laser light output pulses and a power amplifier portion, receiving and amplifying the narrow band seed laser light output pulses into power amplifier laser light output pulses, operating at power amplifier laser light output pulse repetition rates greater than or equal to 4000 per second, in a burst of pulses during an on period, followed by an off period, and having an electrical discharge pulse power system converting energy stored on respective master oscillator and power amplifier charging capacitors into very high voltage, short duration electrical discharge pulses across gas discharge electrodes in each of the master oscillator and power amplifier, through a respective master oscillator and power amplifier multi-stage electrical discharge magnetic pulse compression circuitry and electrical discharge pulse fractional turn voltage step-up transformer, comprising:

measuring the respective laser gas temperature of the gas discharge laser gas in the master oscillator and in the power amplifier and comparing each respective laser gas temperature to a respective temperature threshold signal to get a temperature error signal;

applying a discrete transfer function to the temperature error signal to provided a discretely transferred temperature error signal;

integrating the discretely transferred temperature error signal in a discrete-time integrator;

measuring the respective gas discharge repetition rate for the master oscillator and for the power amplifier and creating a respective repetition rate feed-forward signal and adding the respective repetition rate feed forward signal to the output of the discrete-time integrator;

utilizing the output of the addition of the respective repetition rate feed forward signal and the output of the discrete-time integrator to control the positioning of a respective coolant valve or the output of a respective heater to control the respective laser gas temperature in the master oscillator and the power amplifier.

23. A method of operating a gas discharge excimer laser having a master oscillator portion, producing narrow band seed laser light output pulses and a power amplifier portion, receiving and amplifying the narrow band seed laser light output pulses into power amplifier laser light output pulses, operating at power amplifier laser light output pulse repetition rates greater than or equal to 4000 per second, in a burst of pulses during an on period, followed by an off period, and having an electrical discharge pulse power system converting energy stored on respective master oscillator and power amplifier charging capacitors into very high voltage, short duration electrical discharge pulses across gas discharge electrodes in each of the master oscillator and power amplifier, through a respective master oscillator and power amplifier multi-stage electrical discharge magnetic pulse compression circuitry and electrical discharge pulse fractional turn voltage step-up transformer, comprising:

employing an active gas consumption rate estimate to determine if the active gas consumption, as estimated, exceeds a target active gas consumption and if so to perform an active gas injection;

wherein the determination of the estimated active gas consumption comprises utilizing a moving average of burst average charging voltage and including efficiency loss relative to a baseline efficiency and based upon detecting and responding to operation point changes;

monitoring burst average charging voltage change over a number of bursts and computing a burst average charging voltage change due to operation point changes; and,

adjusting a target charging voltage based upon the observed charging voltage change.